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SWITCHING POWER SUPPLY
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This power supply is a series switching supply (buck regulator). As such it requires a transformer to provide line isolation. Without a transformer, the output terminals are floating with the A.C. mains. With an isolation transformer, the negative output terminal is grounded. In all cases, however, the current control is line isolated and ground referenced, to allow external control from users’ ground referenced (or isolated) circuitry.

2.0 OUTPUT POWER:
This power supply will output up to 50 amperes into laser pump lamps of up to 360 volts for a maximum output power of 18K watts with a 310 A.C. volt input line. Slightly higher voltage lamps may be powered at reduced current depending on line voltage. The power supply, however, is limited depending upon the laser head being driven. For Model 403 and 405 lasers the output current is limited to 40 Amps and the voltage is the lamp arc voltage. For Models 406 and 408 lasers the output current is limited to 50 Amps.

3.0 INPUT POWER:
The power supply requires a 3 phase main line power bus, the voltage and current of which are a function of the laser head being driven. Fusing should be slow-blow fuses or time delay breakers. A single phase 208/230 VAC line is also required for the control circuits of supplies used for 406 & 408 lasers. The power supply is equipped with turn-on current inrush limiting circuitry to minimize line surges. Refer to the Power Requirements chart under SPECIFICATIONS in this manual section.

4.0 REMOTE CONTROL:
The power supply includes a remote control connector (J1). Reference schematic #620002 for 6’ or smaller laser heads and #622003 for 8’ laser head systems. Terminals are provided for remote current control via external potentiometer or externally applied voltage signal. The laser lamp may be externally triggered and the operating current sampled at this J1 connector.

4.1 LOCAL OPERATION:
For operation without remote current control, the following connections must be made at the J1 connector.

Connect:  
J1-1 to J1-2
J1-9 to J1-10
J1-6 to J1-14

4.2 REMOTE CURRENT:
There are two methods of remote current control.

4.21 PASSIVE CURRENT CONTROL:
By varying the resistance between Pins 9 & 10 of J1, the power supply current may be controlled. Typically a 5 K ohm potentiometer is inserted and remotely located. Set the front panel current control
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to maximum and use the inserted potentiometer for remote control.

4.2.2 **ACTIVE CURRENT CONTROL:**
By opening the jumper between pins 1 and 2 of J1, and applying a control voltage to pin #2 the output current can be controlled from minimum (approximately 15 amps) to maximum (50 amps). (Note: Some power supplies are internally limited to 40 amps when operated with certain laser heads)

When operating in this manner, the signal ground should be connected to pin #14 and power ground to pin #6. In true differential signal input applications, pin #14 is the control signal return. The input to output transfer function is \[\approx 2.5 \text{ volts input produces 50 amp output.}\]

5.0 **OPERATION:**
Before applying power to the power supply, insure that the output terminals are properly cabled to the laser head. Never run the power supply with the output terminals open circuited.

5.1 **START-UP:**
Once the cooling pump is started and all interlock conditions are satisfied, the power supply is started as follows:

5.1.1 On the Power Distribution Panel, set the POWER SUPPLY switch to the ON position.

5.1.2 Press the "START" push button to initiate the automatic start sequence. During this sequence additional trigger pulses. If the lamp still does not ignite, the start sequence may be retried by pressing the "START" button again. If unable to ignite the lamp, refer to the diagnostic section.

**NOTE:** If the power supply is energized from the Distribution Panel, but the "START" button is not pressed, the "START" light will still illuminate as a diagnostic check. If this light does not illuminate, refer to the diagnostic section.

6.0 **THEORY OF OPERATION:**
For a typical Model 405 or 406 laser for example, three phase 208 to 235 V.A.C. is rectified and filtered to create D.C. at about 300 volts. The D.C. is applied to a buck regulator circuit. Current is switched through an inductor via an I.G.B.T. semiconductor, driven in a pulse width modulated scheme. The inductor output is filtered, and delivered to the laser lamp.

6.1 **REGULATION:**
The current flowing into the laser lamp is monitored and regulated by the current control circuit (reference schematic #604139 or #625004). This circuit compares the set point current to the laser lamp current and alters the on time pulse width of the I.G.B.T. to maintain the desired current level. The current control circuitry is line isolated to allow interfacing to ground referenced external circuitry.

6.2 **STARTING:**
In order to ignite the laser lamp, three electrical powers are needed. They are: the Bank Voltage, the Boost Voltage, and the Trigger Voltage.
6.2.1 Bank Voltage is present whenever the power supply is turned on. When the lamp is operated, the Trigger Voltage is present.

6.2.2 The Trigger Voltage is a high intensity transient voltage of approximately 20 KV, which is used to initiate the arc lamp plasma streamer.

6.2.3 The Boost Voltage is stored energy at about 900 volts, which enriches the plasma in the arc lamp.

6.3 Starting Circuit Description:
The Trigger Voltage and Boost Voltage are only needed to initiate the arc lamp plasma streamer. These circuits are de-energized once the lamp starts.

6.3.1 (Reference schematic #620002 or #622003) Trigger power is derived from the trigger capacitors (C6 & C7 on #604209) and trigger energy capacitor (C9 on #620002).

6.3.2 Pressing the START button allows full charge to C6, C7, and C9. The spark gap then dumps these stored energies.

7.0 Alignment:
Periodic alignments are not required, but as part of any field repair the following functions should be verified and adjusted when necessary.

7.1 Switching Regulator Circuit:
This circuit board (#604139 or #625004) controls the output current via pulse width modulation. To access this board for in-circuit alignment, a card extender may be required. Reference Figure 1. Disconnect the gate leads from the IGBT and short the IGBT gate terminals together. Energize the main and perform the following alignments.

7.1.1 Input Amplifier:
Energize the power supply. Measure the input signal at pin N. Adjust the front panel Current Control to achieve 2.0 volts at pin N. If unable to reach 2.0 volts, adjust Max. Current control, R44, until greater than 2 volts is obtainable; and trim the front panel control to reach 2.0 volts. Measure the voltage across R80 and adjust R81 (Ref. Cal.) for a reading of 4.0 volts.

7.1.2 Frequency:
View the output of U6, Pin 11 or Pin 14 on an oscilloscope. Adjust R64 for a frequency of 18 KHz.

7.1.3 Maximum Pulse Width:
De-energize the power supply and remove UI from the current sense board #620001. Re-energize the main power. View the gate drive signal at the output of Gate Drive Board #604210 on an oscilloscope. Adjust R51 on 604139 board so that the falling edge of the gate drive precedes the rising edge by 8 microseconds at the baseline. Since there is interaction between the frequency and max pulse width control, retrim the frequency and retrim the pulse width until 18 KHz and 8 μs seconds off time is achieved. De-energize and replace UI.
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7.1.4 LOOP GAIN:
Reconnect the base drive to the IGBT and start the power supply. Apply 2.0 volts to Pin N of the regulator circuit. Adjust R39 (Gain adjust) for an operating current of 40 Amps.

NOTE: If the Over Current set point is too low, the power supply may go into current limit. In that case, increase the resistance of R19, Over Current Limit, to obtain the 40 Amp operating point.

7.1.5 MAXIMUM CURRENT:
Energize the power supply and start the lamp. Turn up the front panel control to maximum, but do not exceed 50 Amps. Adjust Max Current Control R44 for 50 Amps when the front panel control is fully clockwise.

NOTE: During the Max Current Alignment it is possible that the Over Current Circuit may be triggered, if it is set too low. To eliminate this condition, increase the resistance setting of R19 to prevent the current protection circuit from being enabled.

7.1.6 OVER CURRENT LIMIT:
Start the power supply and set the front panel control to provide a current of 50 amps. Slowly turn down the resistance of R19 until the supply current drops or fluctuates. Then increase the setting of R19 by 1-1/2 turns. This procedure completes the regulator circuit board alignment.

7.2 TRIGGER CIRCUIT: (Reference Schematic #604209)
Use two high voltage (100X) scope probes to view the boost voltage and the trigger voltage. Connect one channel to the spark gap at the side which connects to board fingers R&S. This circuit point is the trigger voltage. Connect the other scope channel to the boost voltage at either side of R4. Connect probe grounds to circuit common which is board fingers U, V, M, and N, and the opposite side of the spark gap from above connections.

WARNING!!!

BE SURE THAT THE SCOPE IS ISOLATED AND FLOATING FROM EARTH GROUND. CIRCUIT COMMON IS AT HIGH VOLTAGE. USE CAUTION. DO NOT TOUCH METAL SCOPE FRAME.

Turn on the power supply and press the START button. The trigger voltage should initially rise to R11 so that the trigger voltage is released to rise when boost is at \( \approx 700 \) volts. Adjust R11 so that boost reaches > 800 volts before circuit triggers.

8.0 TROUBLESHOOTING:
This power supply is rugged and industrially rated, and should perform for extended time without
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malfunction. To minimize thermal stresses within the supply, always reduce the output current when laser output is not needed. The supply can be operated directly on 208 to 235 V.A.C., 3Ø lines, 50/60 Hz. when driving 403 to 406 laser lamps. Low line voltage will reduce output capability and reduce cooling air flow. High line voltages, above 240 V.A.C., will put excessive stress on internal components and should not be done, except when operating Model 408 lasers. For operation on high voltage lines, a matching transformer must be used.

WARNING!!!

TROUBLESHOOTING AND REPAIR OF THE POWER SUPPLY REQUIRES OPERATION WITH THE COVERS REMOVED AND HIGH VOLTAGE AREAS EXPOSED. SERVICE OPERATIONS SHOULD ONLY BE PERFORMED BY A QUALIFIED ELECTRONIC TECHNICIAN. ALWAYS ALLOW SEVERAL MINUTES FOR CAPACITORS TO DISCHARGE, AND CHECK THEM WITH A METER BEFORE REMOVING OR REPLACING COMPONENTS.

WARNING!!!

THIS POWER SUPPLY MAY NOT BE LINE ISOLATED. DO NOT CONNECT ANY GROUND REFERENCED TEST EQUIPMENT TO THE POWER CIRCUITS.
In all repair instances involving a failed I.G.B.T., the regulator, gate drive circuit, and snubber assembly should be tested separately prior to re-application of main power.
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POWER SUPPLY TROUBLE SHOOTING:

Supply WILL NOT Deliver Rated Current

Measure Applied Line Voltage, Confirm 3 Phase Connection

Below Specified V. L-L
Correct Facilities Power

Within Specified Range

Check Ripple at C3 #620002, for Full Wave Operation

OK

Check output filter capacitor (C8) Repair if Necessary

OK

Replace Lamp

Situation Persists

Align, Repair or Replace Reg. Circuit Board

Replacing Input FWB

Missing Phases
8.3 POWER SUPPLY TROUBLESHOOTING

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**Power Supply Starts and Goes to Maximum Current - No Current Control**


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**Supply will not Start**

Trouble Shoot - Gate Drive Circuit #604210 and Current Regulator #604319, if required

**Situation Remains**

Replace I.G.B.T. and test all related components - R4, R5, R6, R7, C4, CR4, CR2, CR3, and Gate Drive #604210
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**TROUBLESHOOTING:**

- **Laser Lamp Will Not Ignite**
  - **Start Light Illuminates**
    - Check for Broken Laser Lamp, Replace as Needed
      - **OK**
      - Check for Proper Line Voltage
        - **OK**
        - Check for Bank Voltage on C8
          - **NO**
            - Trace I.G.B.T. gate drive pulse from Regulator #604139 through Gate Drive #604210 - Repair or Replace as Needed
          - **YES**
            - Repair or Replace Trigger Board #604209
  - **Start Light Does Not Illuminate**
    - Check Fuses F1 & F2
      - **OK**
        - Check Water Resistivity. Should be 500K or higher. Flush & Refill, if Needed
      - **Blown**
        - Isolate Loads & Repair as Needed
    - **Check for Bank Voltage on C8**
      - **NO**
        - Trace I.G.B.T. gate drive pulse from Regulator #604139 through Gate Drive #604210 - Repair or Replace as Needed
      - **YES**
        - Test CR5 - Replace as Needed
          - **OK**
            - Check for proper operation of K1 Replace K1 or Repair 604139 Board as needed.
          - **OK**
            - Check T1 for Approx. 750 V.A.C. Output Replace as needed.
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SPECIFICATIONS

SIZE:

   Rack Panel:  19" wide
   Front Panel:  7" High
   Chassis:  17" Wide x 20" Deep plus 2-1/4" for rear connectors

Output Configuration:  Units operating from facilities power are not line

Environment:  Recommended - free air < 80°F

DO NOT OBSTRUCT AIR FLOW.

Internal Power Dissipation:  Approximately 6% of output power.

Control Circuits:  Electrically isolated from power mains and ground referenced. Features: Remote control; remote starting; current monitoring.

POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Laser Model</th>
<th>Line Voltage</th>
<th>Line Current</th>
<th>Fusing</th>
<th>Output Power</th>
<th>Output Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>403</td>
<td>208 VAC</td>
<td>16A</td>
<td>20A</td>
<td>6KW</td>
<td>40A</td>
</tr>
<tr>
<td>404</td>
<td>208 VAC</td>
<td>20A</td>
<td>30A</td>
<td>6KW</td>
<td>40A</td>
</tr>
<tr>
<td>405</td>
<td>208 VAC</td>
<td>28A</td>
<td>40A</td>
<td>8KW</td>
<td>40A</td>
</tr>
<tr>
<td>406</td>
<td>225 to 235</td>
<td>40A</td>
<td>50A</td>
<td>14KW</td>
<td>50A</td>
</tr>
<tr>
<td>408</td>
<td>300 to 310</td>
<td>40A</td>
<td>50A</td>
<td>18KW</td>
<td>50A</td>
</tr>
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